Developing Algorithm Components for GPM Snowfall Retrievals

G. Liu, E. Sims, R. Honeyager, M. Yin – Florida State University; F. J. Turk - JPL

Introduction The goal of this project is to develop algorithm components for snowfall detection and retrieval using GPM/GMI (as well as other microwave radiometers in the constellation) observations. Toward this goal, currently we are working on the following: (1) Develop a snow-rain separation algorithm using data of surface observations, (2) Develop scattering database and approximation method for aggregate snowflakes, (3) Develop an empirical snowfall detection/retrieval algorithm over land, and (4) Develop snow cloud vs. brightness temperature database for snowfall over ocean.

Snow-Rain Separation

A snow-rain parameterization is developed using data:
Land: NCEP ADP Operational Global Surface Observations, 1997-2007
Ocean: International Comprehensive Ocean-Atmosphere Data Set (ICOADS), 1995-2007
Upper Air: Integrated Global Radiosonde Archive (IGRA)

Input variables:

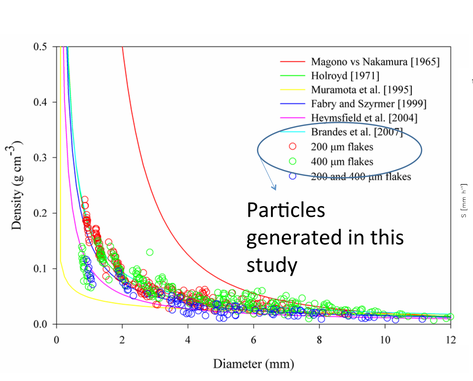
- Air temperature (2 m)
- Humidity (2 m)
- Low-level (0 - 500 m) lapse rate
- Surface skin temperature
- Land or ocean

Output:

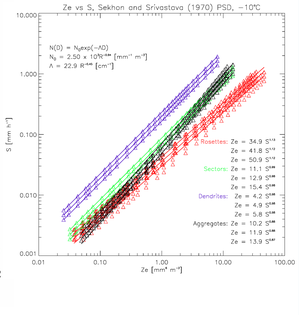
Probability of Solid Precipitation (Sims and Liu, 2015 JHM)

Scattering Database for Aggregates

Aggregate snowflakes have been created with their dimension-mass relation constrained by consensus of observations. Their scattering properties have been calculated using DDA and scattering table is archived on the web. With the addition of table to the earlier table for crystal type particles, we now have the scattering table for full range of ice/snow particles, with types of "rounded", "oblate" and "prolate" aggregates. (Liu, 2008; Nowell et al., 2013; Honeyager et al., 2015).



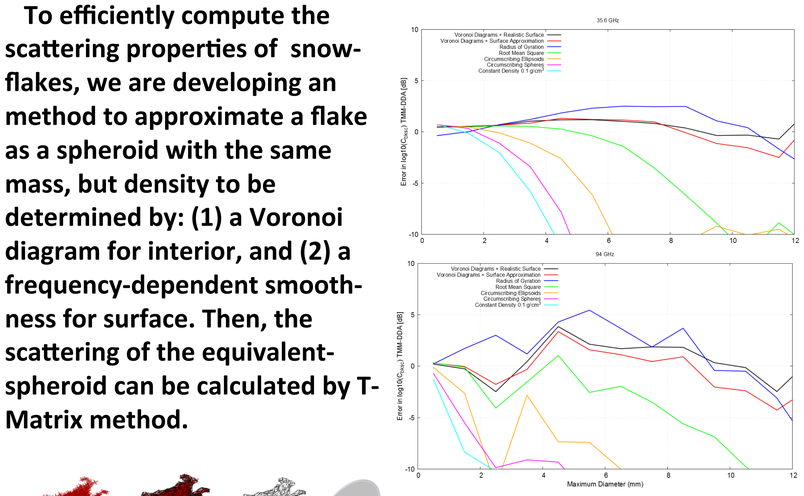
Z-S Relation based on different particle shapes



Approximation Method for the Scattering of Nonspherical Snow Particles

(see Poster #214 tomorrow for detail)

To efficiently compute the scattering properties of snow-flakes, we are developing an method to approximate a flake as a spheroid with the same mass, but density to be determined by: (1) a Voronoi diagram for interior, and (2) a frequency-dependent smooth-ness for surface. Then, the scattering of the equivalent-spheroid can be calculated by T-Matrix method.

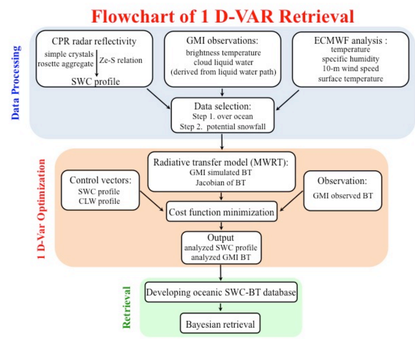


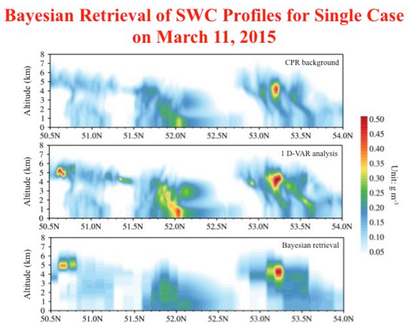
Comparison results of different approximations

1D-Var Approach for Over-Ocean Snowfall Database

(see Poster #238 tomorrow for detail)

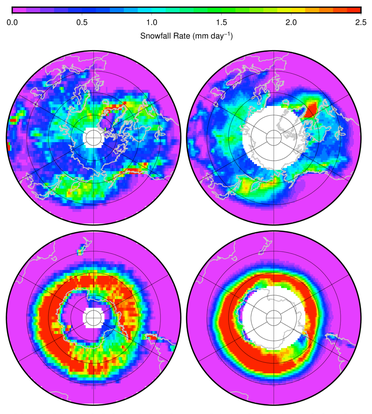
The approach uses merged CloudSat, GPM, and ECMWF data (Turk, 2015). It starts from snow water content (SWC) profiles from CloudSat CPR, uses a radiative transfer model and 1D-Var optimization to obtain a physically consistent snow cloud – GMI brightness temperature database, which may be used for snowfall retrievals as well as cloud processes studies.



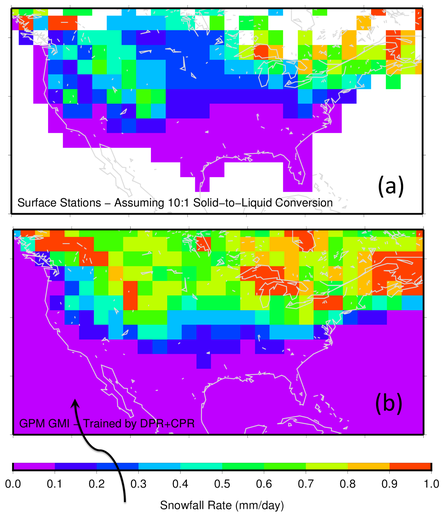


Snowfall Detection and Retrieval over Land

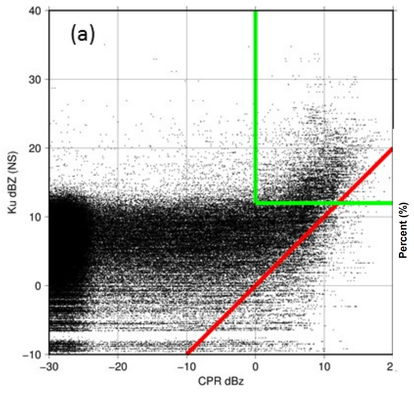
METHOD: The over-land snowfall detection/retrieval algorithm is based on a lookup-table using coincident MW radiometer and radar (as truth) data pairs. From radar reflectivity, first derive snowfall rate using a Z-S relation. Then a lookup table is generated that gives snowfall probability and snowfall rate in 3-D brightness temperature EOF space. (Liu&Seo, 2013)



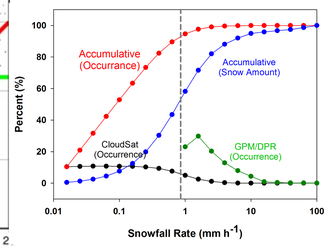
Using the empirical method, snowfall rate are retrieved from GMI brightness temperatures (excluding 10 GHz). Results are compared to CloudSat snowfall and surface station measurements (GHCND).



Use combined CloudSat/CPR and GPM/DPR as "truth": DPR (Ku or Ka) has a minimum detection of about 12 dBZ, missing most of snowfall events, while CloudSat CPR has attenuations for heavy snowfall. Combined DPR-CPR data are used as "truth" in the GPM GMI empirical algorithm. Z-S relations for DPR/CPR are derived from scattering database with assumed size distributions.



Based on collocated CloudSat/CPR - GPM/DPR data: Mar. 2014 – Dec. 2015. Due to its low detectability, DPR may have missed about 50% of snowfall amount.



(a) GHCND + Canada Station observed climatology – multiple years
(b) GMI – 2014.4-2016.3, trained by CloudSat/CPR + GPM/DPR
* Similar pattern – therefore, GMI is able to catch the snowfall signature
* Different magnitude – need more study for "truth" data, Z (radar) to S (snowfall) conversion.

Supported by NASA PMM grant NNX16AE05G